A check in the amount of $110 is enclosed herewith for payment of the extension fee. Please charge any deficiency or credit any excess payment to Deposit Account No. 08-3284 of Intellectual Property/Technology Law.

Cancellation of Claims 56-60

Consistent with the Examiner's finalization of the restriction requirement, and withdrawal of claims 58-60, such claims have been cancelled herein. Such cancellation is with express reservation of the right to file a further divisional application directed to the subject matter of such claims, during the pendency of the present application, or during the pendency of a further continuation or divisional application based on and claiming the priority of the present application.

Claims 56 and 57 have also been cancelled herein.

Response to Objections of Claim 40-57

In the July 24, 2001 Office Action, the Examiner objected to claims 40-57 for failure to clearly define the oxygen content in the ferroelectric oxide layer in a depth deeper than 25 Angstroms.

In response, applicants have cancelled claims 56-57 and amended claim 40, upon which pending claims 41-55 depend, to define a ferroelectric oxide or high ε oxide film material that is "**stoichiometrically complete in oxygen content throughout**, including the top surface region of the ferroelectric oxide or high ε oxide film material".

The amended claims 40 and its dependent claims 41-55 clearly define the oxygen content in the ferroelectric oxide or high ε oxide film material, by using the word "throughout", and therefore overcome the objection as raised by the Examiner in the July 24, 2001 Office Action.

Response to 112 Rejection of Claim 53

The Examiner rejected claim 53 for lack of teaching about how to incorporate excess oxygen content in the lattice portion of the ferroelectric oxide or high ε oxide film material.

In response, claim 53 has been amended by removing the recital of "oxygen content in excess of said stoichiometric oxygen requirement of said ferroelectric oxide or high ε oxide film material is present in a lattice portion of said material in said top surface region."

Therefore, claim 53 as amended overcomes the 112 rejection.

Response to 103 Rejections of Claims 40-57

In the July 24, 2001 Office Action, the Examiner rejected claims 40-57 under 35 U.S.C. §103(a) as being obvious over Nishioka U.S. Patent No. 5,973,911 (hereinafter "Nishioka") and Larson et al. U.S. Patent No. 5,216,572 (hereinafter "Larson").

In response, applicants have cancelled claims 56-57 and amended claims 40 and 52-55.

Applicants hereby traverse the rejections of pending claims 40-55 as amended, based on the following reasons.

Claim 40 as amended, from which claims 41-55 depend, recites:

> "A microelectronic device structure including a top electrode layer on a top surface of a ferroelectric oxide or high ε oxide film material, wherein said ferroelectric oxide or high ε oxide film material is **stoichiometrically complete in oxygen content throughout**, including the top surface region of the ferroelectric oxide or high ε oxide film material, and **wherein the top electrode layer does not contain oxygen abstracted from the thin film of ferroelectric or high ε material underneath**."

Claim 52 has been amended to require that the top electrode layer be formed in an oxygen-enriched environment, and claims 53-55 have been amended to further define the specific process for forming the top electrode layer in an oxygen-enriched environment.

The top electrode layer of applicants' claimed invention has been pre-saturated with oxygen during forming of such top electrode layer, for example, by forming the top electrode layer in an oxygen-enriched environment, and such pre-saturated top electrode layer does not abstract or "draw" oxygen content from the ferroelectric or high ε material underneath, while unsaturated electrode layer usually

does. As a result, the oxygen loss usually suffered by the ferroelectric or high ε material during formation of the top electrode layer is effectively prevented.

The top electrode layer, which "**does not contain oxygen abstracted from the ferroelectric or high ε film material underneath**", as recited by amended claims 40-56, **structurally distinguishes** over the oxygen-abstracting top electrode layers disclosed by the cited references.

Nishioka teaches a method for making a ferroelectric thin film capacitor, by sputtering an upper Pt electrode over a ferroelectric film of high permittivity first, and then heat-treating said capacitor in an oxidizing atmosphere to eliminate any oxygen holes in the ferroelectric thin film caused by the sputtering (see Nishioka, column 1, lines 52-57).

Nothing in Nishioka teaches or suggests forming the upper Pt electrode in an oxygen-enriched environment. An upper Pt electrode formed under normal conditions, i.e. without oxygen enrichment, is not saturated with oxygen and has a tendency to abstract oxygen content from the ferroelectric material underneath.

Therefore, the upper Pt electrode disclosed by Nishioka inevitably contains oxygen content abstracted from the ferroelectric layer underneath and does not satisfy the express requirements of applicants' claims 40-56.

Larson discloses a ferroelectric capacitor with a ferroelectric material layer, wherein the ferroelectric material layer comprises an ion implantation region formed in the top surface thereof (see Larson, column 6, lines 14-16). Such ion implantation region may be ion implanted with oxygen (see Larson, column 6, line 18).

However, ion implanting the top surface region of the ferroelectric material with oxygen does not prevent the subsequently deposited top electrode layer from abstracting oxygen content out of said ferroelectric material. There is no teaching or suggestion in Larson about forming the top electrode layer in an oxygen-enriched environment. Therefore, the top electrode layer of Larson is not pre-saturated with oxygen and will subsequently abstract oxygen content from the underlying ferroelectric material layer.

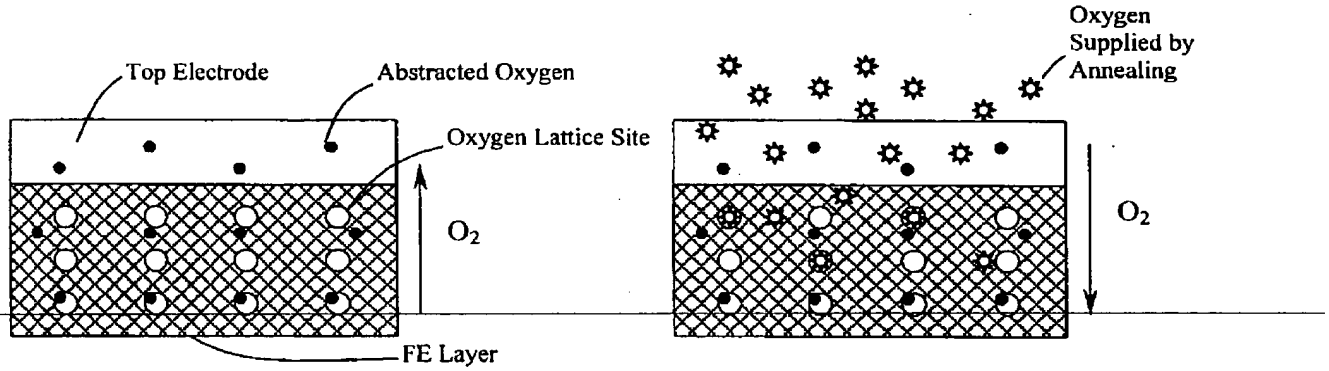
Such top electrode layer of Larson, which inevitably contains oxygen content abstracted from the ferroelectric or high ε film material underneath, does not provide any derivative or extrapolative basis for

a top electrode layer that "does not contain oxygen abstracted from the thin film of ferroelectric or high ε material underneath," as required by applicants' claimed invention in claims 40-56.

Therefore, applicants' claimed invention patentably distinguishes over Nishioka and Larson, by expressly requiring a top electrode layer that "does not contain oxygen abstracted from the thin film of ferroelectric or high ε oxide material underneath."

Applicants' claimed invention, by forming a top electrode layer pre-saturated with oxygen and by preventing subsequent abstraction of oxygen from the ferroelectric material during the formation of the top electrode layer, effectively **preserves the original lattice structure** of the ferroelectric or high ε oxide material.

The process disclosed by Nishioka involves an initial loss of oxygen content in the ferroelectric material, and a subsequent diffusion of oxygen from external environment through the upper electrode into the ferroelectric material, as illustrated below:

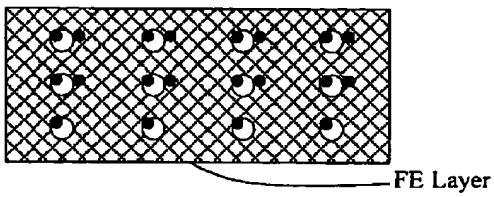


Abstraction of Oxygen by Top Electrode Diffusion of Oxygen into FE Layer

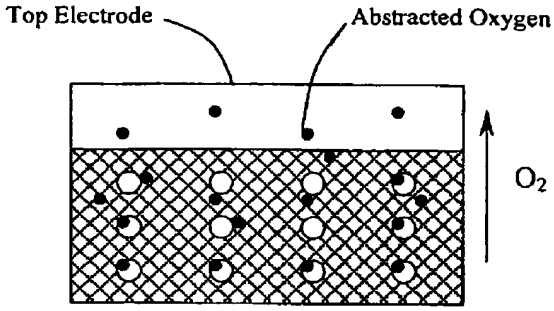
The initial oxygen abstraction/loss by the top electrode layer, as shown hereinabove, destroys the original lattice structure of the ferroelectric material and leaves oxygen vacancy in the lattice structure. The subsequent supply of oxygen by heat-annealing in an oxidizing environment does not completely restore the original lattice structure in the ferroelectric material and leaves a disordered lattice structure.

Moreover, diffusion of atomic oxygen into the ferroelectric film will necessarily entail the formation of an oxygen concentration gradient in the ferroelectric material film. Therefore, oxygen content in the post-diffusion ferroelectric material will be non-homogeneous in stoichiometry.

Larson only discloses initial incorporation of excess oxygen in the ferroelectric material layer, which, although it compensates for subsequent oxygen loss, still leaves a disordered lattice structure and a non-homogeneous oxygen concentration throughout the ferroelectric material layer, as shown below:

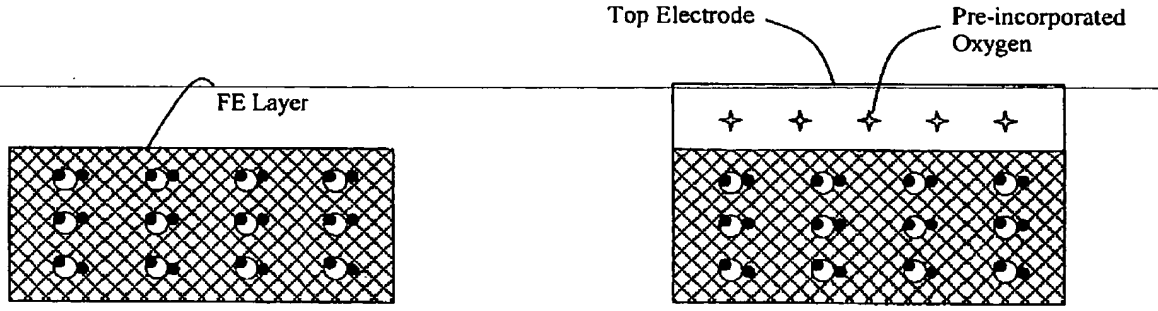


Ion Implanted FE Structure



Subsequent Abstraction of Oxygen by Top Electrode

In contrast, applicants' claimed invention, by forming a top electrode pre-saturated with oxygen, prevents abstraction of oxygen by the top electrode, and therefore advantageously preserves the original lattice structure and a homogeneous oxygen content throughout the ferroelectric or high ε oxide material, as shown below:



Based on the foregoing, applicants respectfully request the Examiner to reconsider, and upon reconsideration, to withdraw the rejections of claims 40-55 as amended.

Addition of New Claims 61-63

Claims 61-63 have hereby been added to specify preferred embodiments of the present invention. The subject matter of the new claims 61-63 is disclosed by the specification as originally filed, and no new matter is introduced by such new claims.

Claims 61-62 directly depend from claim 40, and claim 63 recites limitations similar to those of claim 40 as discussed hereinabove. Therefore, claims 61-63 also patentably distinguish over the cited references and are in form and condition for allowance.

The addition of new claims 61-63, with the cancellation of claims 56-60 herein, does not increase the number of total claims beyond the number for which payment was previously made. Nevertheless, if any fee or charge is deemed properly payable in connection with the entry of this Amendment, the United States Patent and Trademark Office is hereby authorized to charge any payment necessary to the entry of this Amendment, to Deposit Account No. 08-3284 of Intellectual Property/Technology Law.

CONCLUSION

In view of all the foregoing, pending claims 40-55 and 61-63 as amended/added herein are in form and condition for allowance. Issue of a Notice of Allowance therefore is respectfully requested.

If any issues remain outstanding, the Examiner is requested to contact the undersigned at (919) 419-9350 to discuss their resolution, and expedite closure of prosecution on the merits in favor of allowance of claims 40-55 and 61-63.

Respectfully submitted,

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LIMITED RECOGNITION UNDER 37 CFR § 10.9(b)

Yongzhi Yang is hereby given limited recognition under 37 CFR § 10.9(b) as an employee of Steven J. Hultquist to prepare and prosecute patent applications wherein the patent applicant is the client of Steven J. Hultquist, and the attorney or agent of record in the applications is a registered practitioner who is a member of the Intellectual Property/Technology Law firm. This limited recognition shall expire on the date appearing below, or when whichever of the following events first occurs prior to the date appearing below: (i) Yongzhi Yang ceases to lawfully reside in the United States, (ii) Yongzhi Yang's employment with Steven J. Hultquist ceases or is terminated, or (iii) Yongzhi Yang ceases to remain or reside in the United States on an H-1 visa.

This document constitutes proof of such recognition. The original of this document is on file in the Office of Enrollment and Discipline of the U.S. Patent and Trademark Office.

Expires: August 23, 2002

Harry I. Moatz
Director of Enrollment and Discipline

Appendix A –Version with Markings to Show Changes Made

40. (amended) A microelectronic device structure including a top electrode layer on a top surface of a ferroelectric oxide or high ε oxide film material, wherein said ferroelectric oxide or high ε oxide film material [having a stoichiometric oxygen requirement, wherein a top surface region of the ferroelectric oxide or high ε oxide film material including said top surface and said ferroelectric oxide or high ε oxide film material within a depth of 25 Angstroms measured from said top surface has an oxygen content equal to or in excess of said stoichiometric oxygen requirement of said ferroelectric oxide or high ε oxide film material] is stoichiometrically complete in oxygen content throughout, including the top surface region of the ferroelectric oxide or high ε oxide film material, and wherein the top electrode layer does not contain oxygen abstracted from the thin film of ferroelectric or high ε material underneath.

52. (amended) A microelectronic device structure according to claim 40, wherein the top [surface region of the ferroelectric oxide or high ε oxide film material has an oxygen content in excess of said stoichiometric oxygen requirement of said ferroelectric oxide or high ε oxide film material] electrode is formed in an oxygen-enriched environment.

53. (amended) A microelectronic device structure according to claim [52] 40, wherein said [oxygen content in excess of said stoichiometric oxygen requirement of said ferroelectric oxide or high ε oxide film material is present in a lattice portion of said material in said top surface region] top electrode is formed of a metallic non-oxide material by sputtering in the presence of oxygen.

54. (amended) A microelectronic device structure according to claim [52] 40, wherein said [oxygen content in excess of said stoichiometric oxygen requirement of said ferroelectric oxide or high ε oxide film material is present in grain boundaries of said material in said top surface region] top electrode is formed of a noble metal that is formed by evaporation of a noble metal source material in the presence of oxygen.

55. (amended) A microelectronic device structure according to claim 40, wherein the top electrode layer is formed of a [pure] noble metal by a chemical vapor deposition process that incorporates oxygen.

56. (cancelled).

57. (cancelled).

58. (cancelled).

59. (cancelled).

60. (cancelled).

61. (new).

62. (new).

63. (new).

Appendix B – All Pending Claims

40. A microelectronic device structure including a top electrode layer on a top surface of a ferroelectric oxide or high ε oxide film material, wherein said ferroelectric oxide or high ε oxide film material is stoichiometrically complete in oxygen content throughout, including the top surface region of the ferroelectric oxide or high ε oxide film material, and wherein the top electrode layer does not contain oxygen abstracted from the thin film of ferroelectric or high ε material underneath.

41. A microelectronic device structure according to claim 40, wherein said ferroelectric or high ε film comprises an oxide perovskite or layered structure perovskite.

42. A microelectronic device structure according to claim 40, wherein said ferroelectric or high ε film comprises a material selected from the group consisting of lead zirconium titanate, barium and/or strontium titanates, and strontium bismuth tantalates.

43. A microelectronic device structure according to claim 40, wherein said ferroelectric or high ε film comprises a lead zirconium titanate material.

44. A microelectronic device structure according to claim 40, wherein said ferroelectric or high ε film comprises a barium and/or strontium titanate material.

45. A microelectronic device structure according to claim 40, wherein said ferroelectric or high ε film comprises a strontium bismuth tantalate material.

46. A microelectronic device structure according to claim 40, wherein said top electrode layer comprises a material selected from Pt, Pt oxides, Ir, Ir oxides, Pd, Pd oxides, Rh, Rh oxides, and compatible mixtures and alloys of the foregoing.

47. A microelectronic device structure according to claim 40, wherein said top electrode layer comprises a Pt material.

48. A microelectronic device structure according to claim 40, wherein said top electrode layer comprises a Pt oxide material.

49. A microelectronic device structure according to claim 40, wherein said top electrode layer is formed of Ir.

50. A microelectronic device structure according to claim 40, wherein said top electrode layer comprises an Ir oxide material.

51. A microelectronic device structure according to claim 40, wherein the top electrode layer is formed of Ir or IrO_2.

52. A microelectronic device structure according to claim 40, wherein the top electrode is formed in an oxygen-enriched environment.

53. A microelectronic device structure according to claim 40, wherein said top electrode is formed of a metallic non-oxide material by sputtering in the presence of oxygen.

54. A microelectronic device structure according to claim 40, wherein said top electrode is formed of a noble metal that is formed by evaporation of a noble metal source material in the presence of oxygen.

55. A microelectronic device structure according to claim 40, wherein the top electrode layer is formed of a noble metal by a chemical vapor deposition process that incorporates oxygen.

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61. A microelectronic device structure according to claim 40, wherein said top electrode layer comprises Rh.

62. A microelectronic device structure according to claim 40, wherein said top electrode layer comprises a Rh oxide material.

63. A ferroelectric or high ε capacitor comprising:

a bottom electrode layer formed of a material selected from the group consisting of Ir, Ir oxide, Rh, Rh oxides, and compatible mixtures and alloys thereof;

a thin film of a ferroelectric or high ε material over the bottom electrode, wherein the material is stoichiometrically satisfied in oxygen content throughout, including the surface region of the material adjacent to the top electrode layer;

a top electrode layer on the thin film of ferroelectric or high ε material, which is formed of a material selected from the group consisting of Ir, Ir oxide, Rh, Rh oxides and compatible mixtures and alloys thereof,

wherein

the top electrode layer does not contain oxygen abstracted from the thin film of ferroelectric or high ε material underneath.

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In re U.S. Patent of:	Advanced Technology Materials, Inc.
Patent Appl. No.:	09/200,495
Filing Date:	25 November 1998
Title:	OXIDATIVE TOP ELECTRODE DEPOSITION PROCESS, AND MICROELECTRONIC DEVICE STRUCTURE
Date Mailed:	November 26, 2001
Express Mail Label:	EL037732817US
Attorney Ref.:	2771-337 RCE

the refusal of the U.S. Postal Service to accept the attempted Express Mail, consistent with the October 9, 2001 Official Gazette notification and procedure (37 CFR 1.6(e)).

Respectfully submitted,

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